

HENSLOW'S SPARROW HABITAT ASSOCIATIONS ON KANSAS TALLGRASS PRAIRIE

JACK F. CULLY, JR.^{1,2} AND HEIDI L. MICHAELS¹

ABSTRACT.—We examined macro- and microhabitat characteristics of breeding Henslow's Sparrows (*Ammodramus henslowii*) on Fort Riley Military Reservation, Kansas during 1995 and 1996. Survey points were identified at the macrohabitat scale as either grassland, savanna, or woodland edge. A military disturbance index was used to quantify the severity of training disturbance to the vegetation at survey and bird use sites. At the large scale, Henslow's Sparrows were associated with grassland habitat last burned in 1993, two or three years previously. Microhabitat at Henslow's Sparrow use sites had lower tree density than random survey points, but neither shrub density nor military disturbance index differed between use sites and survey points during spring. In summer, the military track index was higher on Henslow's Sparrow's use sites. Habitat used by Henslow's Sparrows was consistently tall and dense vegetation with high litter cover during early spring, late spring, and summer whereas the vegetation of random survey points changed in response to vegetation growth. Characteristics of Henslow's Sparrow use sites included high cover by litter and dense, structurally homogeneous vegetation, whereas litter depth and standing dead vegetation, physiognomic diversity, and military disturbance did not differ from random survey points. Received 10 May 1999, accepted 5 Sept. 1999.

Many grassland birds of the Midwest and the Northeast have experienced severe population declines since 1950 (Robbins et al. 1986, Herkert 1994a). These declines coincide with significant reductions in grassland habitat throughout these regions (Smith 1981, Askins 1993, Samson and Knopf 1994). Henslow's Sparrow (*Ammodramus henslowii*) has declined throughout its range at a rate of 9.0% per year from 1966 to 1996 (Sauer et al. 1997) and thus has been included on the National Audubon Society's Blue List of declining species since 1974 (Arbib 1979; Tate 1981, 1986; Tate and Tate 1982). The species was identified as a migratory nongame species of management concern in 1987 (U.S. Fish and Wildlife Service 1987, 1995; Schneider and Pence 1992; Pruitt 1995), is designated as a Species in Need of Conservation in Kansas (Kansas Department of Wildlife and Parks 1986), and concern for the species continues.

Henslow's Sparrows are believed to require areas of tallgrass prairie that are at least 30 ha and that have not been recently disturbed by events such as fire (Zimmerman 1988, 1992; Herkert 1994b) or haying for one or more years (Herkert 1994b, Swengel 1996). Henslow's Sparrows require vegetation that is tall

and dense, especially within 25–40 cm of the ground (Kahl et al. 1985, Zimmerman 1988). Zimmerman (1988) suggested that the presence of standing dead vegetation reduces live growth and provides open areas at ground level for foraging Henslow's Sparrows.

This study was developed with two major objectives: to determine the habitat selected by Henslow's Sparrows on Fort Riley at both the fine scale (the scale of habitat within individual territories) and the larger scale of plant community type, and to determine if a relationship exists between the intensity of military training disturbance to the vegetation and habitat selected by Henslow's Sparrows.

METHODS

Study area.—Fort Riley (39° 15' N, 96° 50' W), Kansas lies in the Flint Hills, which extend from Nebraska across Kansas and into Oklahoma. The Flint Hills are the largest remaining area of tallgrass prairie in the world (Reichman 1987) and occur near the western edge of Henslow's Sparrow range (Sauer et al. 1997). Most of the private land in the Flint Hills is used for cattle grazing. Grazing, hay harvest, and annual burning on Flint Hills pastures alter the tallgrass prairie by reducing litter and dense vegetation near the ground, which reduces habitat quality for Henslow's Sparrows (Zimmerman 1988). Fort Riley is a 40,273 ha permanent U.S. Army Forces Command installation and is the site of ongoing military training. Fort Riley is the largest expanse of public land in the Flint Hills and unlike private land, cattle grazing is excluded. There is mechanical disturbance in the form of mechanized artillery training and some hay cutting of native tallgrass species. Unlike the private rangelands in the

¹ Kansas Cooperative Fish and Wildlife Research Unit, U.S. Geological Survey-Biological Resources Division, Division of Biology, 204 Leasure Hall, Kansas State Univ., Manhattan, KS 66506.

² Corresponding author; Email: bcully@ksu.edu

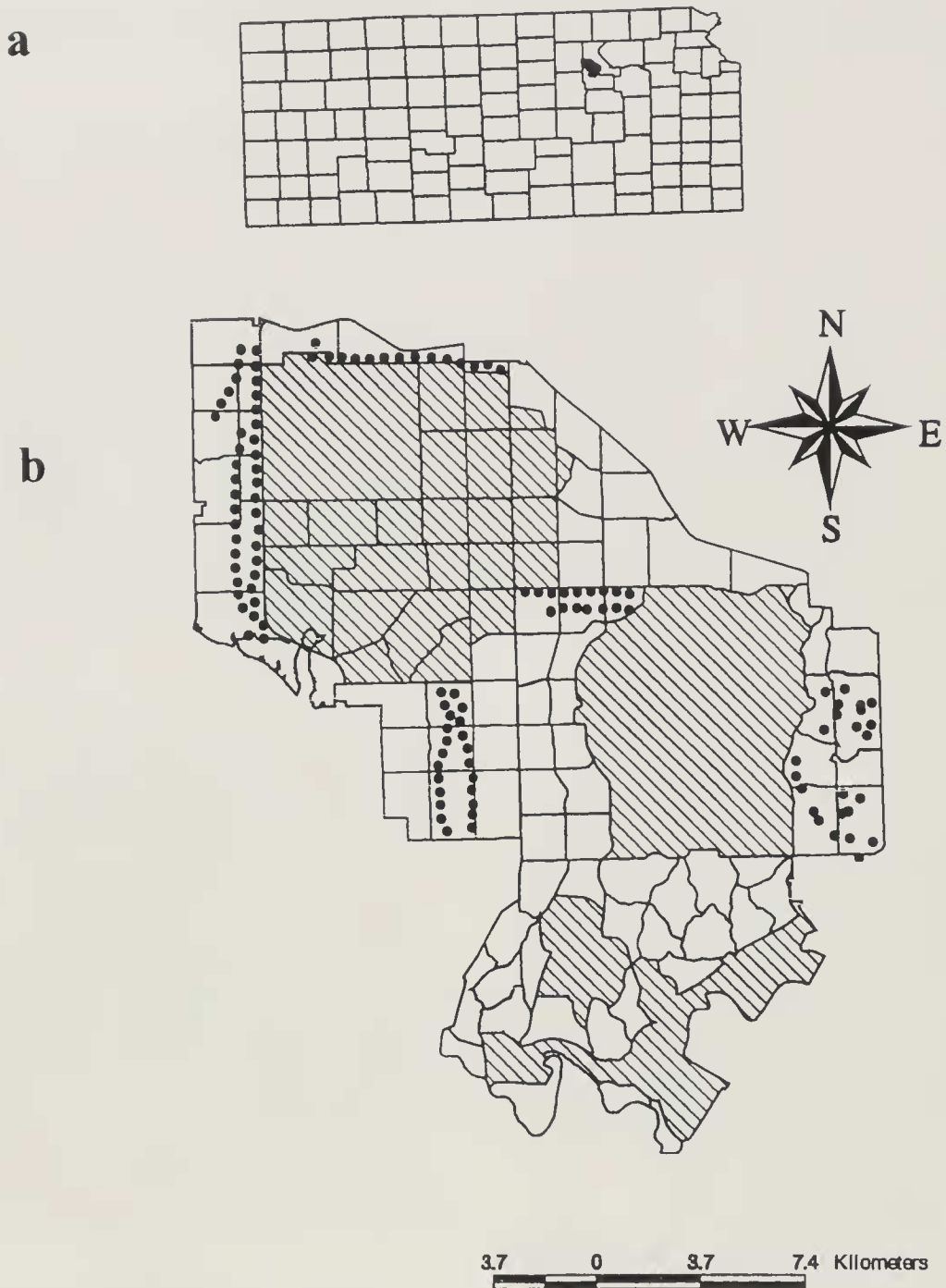


FIG 1. A. Location of Fort Riley Military Reservation, Kansas. B. Location of areas of restricted public access. Access is limited in the Multipurpose Range Complex, shaded area in northwest, and is never available in the impact zone, the shaded area in the center of the fort. The shaded areas in the south are cantonment areas. We placed the census points (circles) in tallgrass prairie habitat where access was most available (from Michaels and Cully 1998).

Flint Hills, most of which are burned annually. Fort Riley has a prescribed burn program that strives to burn at three year intervals. Thus, Fort Riley may have the largest tract of potential Henslow's Sparrow habitat in Kansas.

Bird surveys.—In 1995, 119 permanent bird survey points (survey points) were located in upland grassland habitats in areas of Ft. Riley with minimum access restrictions (Fig. 1) approximately 500 m apart along transects ranging from 5 to 7 km in length. Each survey point was marked with flagged fence posts (Fig. 1). Each transect was surveyed beginning at first light

and was completed within three hours after sunrise. Surveys were not conducted during heavy fog, rain, or when wind speeds exceeded 20 km/hr. To minimize sampling bias, the order in which transects were surveyed each month and the starting point and direction in which points were sampled along the transect were varied randomly. A small number of survey points were excluded from analysis each year because military activity prevented access or the field was cut for hay prior to microhabitat measurements. From May to August, 1995 and from March to July, 1996 five-minute timed monthly surveys were conducted at each sur-

vey point using a modified variable circular plot method (Reynolds et al. 1980) to locate breeding Henslow's Sparrows. The Universal Transverse Mercator coordinates of the exact location of each Henslow's Sparrow seen or heard was recorded with a Global Positioning System unit as a Henslow's Sparrow use site. The date each bird was observed, the activity of the bird, and the type of perch being used (e.g., tree, shrub) when the bird was first located were recorded.

Birds were assumed to be defending a breeding territory at a site if a singing male was relocated at the same site on three or more subsequent morning visits (see Herkert 1994a). Birds making up loose breeding colonies (Wiens 1969) were determined to be independent breeding individuals based on territorial behavior, primarily simultaneous singing. The largest number of Henslow's Sparrows seen singing from a survey point on any of the monthly censuses during 1995 or 1996 was assumed to be the number of breeding pairs associated with that point that year. Thus, no bird was counted more than once during each year. Microhabitat data at Henslow's Sparrow use sites was only measured during 1996 so individual birds were only counted once for the microhabitat analyses. Separate analyses of macrohabitat association were made for the two years.

Large scale habitat.—An initial large scale habitat analysis of upland grasslands on Fort Riley was made using a tree-cover map developed by the Kansas Biological Survey (Lauver et al. 1996) and onsite visual estimates. Large scale habitats were defined for 250 m radius patches (19.6 ha) as grassland ($n = 35$) if plots contained fewer than 15 isolated shrubs (<4 m tall) or trees (>4 m tall) or no more than one copse less than 20 m in diameter. Savanna plots ($n = 44$) contained greater than 15 shrubs or trees but did not contain continuous, wooded riparian habitat. Woodland edge points ($n = 40$) were located within 100 m of extensive, wooded riparian habitat that ran through the plot. All of the survey points were placed in tallgrass prairie habitat. The landscape habitat category of specific Henslow's Sparrow use sites was determined with the same methods used for the survey points.

Permanent bird survey points and Henslow's Sparrow use sites were grouped into five burn treatments based on the year the site was last burned, and two hay treatments based on whether or not the site was cut for hay in 1995. A χ^2 test (SAS version 6.12 on a PC) was conducted to determine if the observed frequencies of Henslow's Sparrow use sites among the three habitat types, among the burn treatments, and among the hay treatments differed from the proportion of survey points in each treatment.

Fine scale vegetative structure.—Fine scale vegetation structure was sampled at Henslow's Sparrow use sites during the spring and summer of 1996 and at survey points during spring 1996 and summer 1995. One hectare sampling grids for survey points were permanently located randomly within 200 m of each survey point. One hectare vegetation sampling grids were also centered on Henslow's Sparrow use sites in order

to describe Henslow's Sparrow fine scale habitat. The density of shrubs (<4 m in height) and trees (>4 m in height) was counted within the 1 ha sampling grid.

A point-intercept method was developed (Michaels and Cully 1998, modified from Rotenberry and Wiens 1980) to sample the structure of the herbaceous vegetation at each survey site and Henslow's Sparrow use site. Within the 1 ha sampling grid, 100 randomly located sampling points were selected. At each of the 100 points a 6 mm diameter rod marked at 10 cm intervals was dropped through the vegetation to record the vertical density of the vegetation as the number of contacts between the pole and vegetation in 10 cm intervals. At each sampling point, the number of contacts of vegetation within each decimeter of the sampling rod was recorded according to the physiognomic class (live grasses, live forbs, standing dead vegetation). These samples were used to calculate measures of herbaceous vegetative cover and vertical and horizontal vegetative structure. Total vegetative cover was estimated as the number of points with at least one of the physiognomic classes of vegetation. Percent cover by each physiognomic class present at a site was calculated from the frequency of occurrence of each class at all 100 sampling points. Physiognomic cover diversity (P) was calculated to show relative structural diversity of the vegetation using the reciprocal of Simpson's (1949) diversity index as

$$P = 1/\sum p_i^2,$$

where p_i is the proportional coverage of the i^{th} physiognomic class (Hill 1973, Wiens and Rotenberry 1981). This index can be understood to measure the effective number of physiognomic classes present in a sample, which could vary from one to three (live grass, live forb, and standing dead). Percent cover of litter was calculated as the number of points that contacted litter. When litter was present, its depth (cm) was measured and recorded. The maximum height of vegetation contacting the rod was also recorded. The vertical density of the vegetation was calculated as the mean number of contacts of vegetation with the rod. Two heterogeneity measures were calculated. The first is the coefficient of variation of the maximum height of the vegetation across the sampling plot. The second is the coefficient of variation of the vertical density of the vegetation across the sampling plot.

The severity of military disturbance to the vegetation was quantified at the fine scale. If disturbance was intercepted by the sampling rod, the sampling point was given a score indicating the intensity of disturbance: 1 (crushed vegetation, little soil disturbance), 2 (extensive disruption of the soil, little remaining vegetation), or 3 (permanent gravel road). A military disturbance index was calculated for each site as the sum of the disturbance scores for all 100 sampling points within the plot.

Principal components analysis.—The spring 1996 survey points encompassed the range of fine scale vegetative conditions available to grassland bird species at Fort Riley at the time when they were establishing

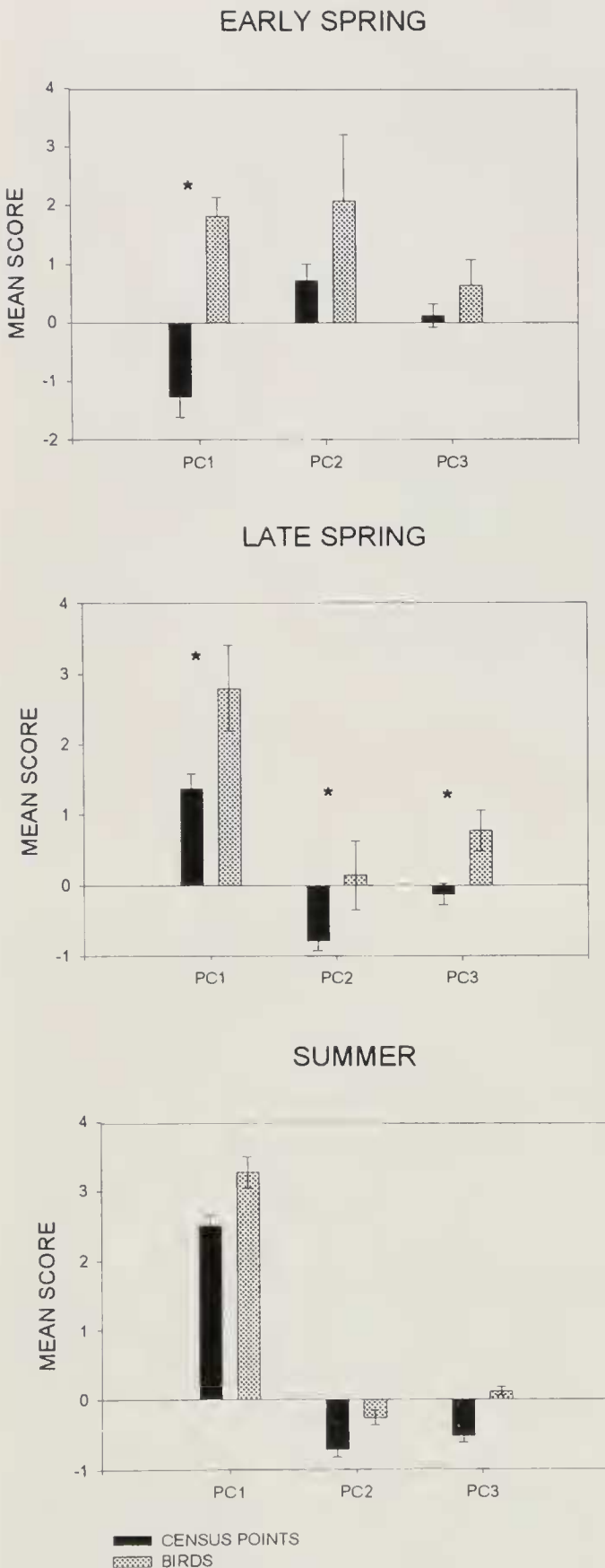


FIG. 2. Principal components scores of permanent bird survey points and Henslow's Sparrow bird entered points at Fort Riley Military Reservation, Kansas. See text for description of microhabitat variables associated with principal component axes.

territories (Zimmerman 1988). For this reason, these data were used as the baseline data for all comparisons. Because measures of vegetative structure are highly correlated with one another (James 1971, Wiens and Rotenberry 1981), a principal components analysis (PCA) was conducted (using SAS, Version 6.12 on a PC) on the spring data to identify the patterns of covariation among the herbaceous vegetation variables. Principal components analysis has the advantage of reducing a large number of covarying variables to a smaller number of orthogonal components that maximize the variance accounted for in the data (Rotenberry and Wiens 1980, Gaueh 1982). Habitat data from the Henslow's Sparrow use sites were also collected as at the survey points. The fine scale habitat data from Henslow's Sparrow use sites were then applied to the spring principal components to ordinate Henslow's Sparrow use sites in the principal component space defined by the survey points. By plotting Henslow's Sparrow use sites vegetation data in the principal component space defined by the spring survey point vegetation data, comparisons of the principal component scores using analysis of variance (ANOVA) could be made between use sites and survey points in order to detect non-random patterns of bird-habitat associations (Michaels and Cully 1998). Likewise, this method makes it possible to assess how the habitat at the survey points changed in PCA space as a result of plant growth as the seasons advanced. Spring vegetation was sampled with the intent of measuring the survey point vegetation in April, prior to the beginning of the growing season. However, because a reservation-wide training exercise announced in late April eliminated access to most of the study site during late April and early May, approximately half of the survey points were not sampled until after the beginning of the growing season in late May. The baseline principal components analysis, to which other samples were compared, was made up of the combined early and late spring fine-scale vegetation data. A series of ANOVAs conducted on the principal component scores for sites sampled before and after the closure showed significant changes in the three significant principal components. For this reason, the spring 1996 sampling period was treated as two separate sampling periods (early and late) and the principal component scores were grouped accordingly for further analysis. Early spring Henslow's Sparrow use sites included sites identified prior to 15 May, late spring from 16 May to 30 June, and summer, later than 30 June. All variables expressed as percentages were transformed using the arcsine square root transformation (Zar 1984) prior to analysis. Data are presented as mean (\bar{x}) \pm standard error (SE). Significance was established at $P = 0.05$ for all comparisons.

The Shapiro-Wilk test (SAS Institute, Inc. 1992) was used to test the univariate assumption that the data were normally distributed and Levene's test (Milliken and Johnson 1984) was used to test the univariate assumption that the treatment group variances were equal. When the treatment variances were unequal, the SATTERTH option within the PROC MIXED proce-

ture in SAS (SAS Institute, Inc. 1992) on a PC was employed to calculate appropriate degrees of freedom and fit the unequal variance model. If the Satterthwaite method did not change the results of the ANOVA, the test was assumed to be robust despite the heterogeneous variances and the original data were retained. If, by fitting the unequal variance model, the results of the ANOVA changed, the test was conducted using the new degrees of freedom.

RESULTS

Large scale.—During 1995, 36 singing male Henslow's Sparrows were located. Several of the singing males were found together, a pattern similar to the loose breeding colonies noted by Hyde (1939) and Wiens (1969). Most 1995 Henslow's Sparrow use sites (21 of 36) were located in grassland, 10 in savanna and 5 associated with woodland edge points ($\chi^2 = 10.8$; 2 df; $P = 0.005$). In separate 2×2 tests, grassland was selected more frequently than savanna ($\chi^2 = 4.9$; 1 df; $P < 0.03$), but savanna and woodland edge did not differ ($\chi^2 = 1.0$; 1 df; $P > 0.05$). In 1996, 21 Henslow's Sparrows were observed at survey points; 13 in grassland, 4 in savanna, and 4 in woodland ($\chi^2 = 8.4$; 2 df; $P < 0.02$). As in 1995, 2×2 tests showed grassland habitat significantly more frequently used than savanna or woodland edge ($\chi^2 = 5.8$; 1 df; $P < 0.02$), which were equal. Only 3 of 12 survey points that yielded Henslow's Sparrows in 1996 also had the species in 1995. In 1996, Henslow's Sparrows only used sites that were not hayed the year before. Approximately 30% of the study area was hayed in 1995 (33 of 104 sites); however, only 5 were at sites identified as grassland. The distribution among burn treatments of Henslow's Sparrow sites in 1995 was significantly different from that expected ($\chi^2 = 10.49$; 4 df; $P = 0.03$) with the majority (22 of 24) of Henslow's Sparrows selecting sites burned either two (15) or three (7) years previously (1993 and 1992). During 1996, at 21 Henslow's Sparrow use sites, 2 sites were burned two years earlier (1994); 18 sites were burned three years earlier (1993), and one site was burned four years earlier ($\chi^2 = 50.56$; 4 df; $P < 0.0001$). Thirty-three of 45 sites (73%) used by Henslow's Sparrows during 1995 and 1996 were burned in 1993.

Fine scale.—The PCA of the spring 1996 fine scale vegetation of the 13 microhabitat variables resulted in three principal compo-

nents with eigenvalues greater than one. Together these accounted for 84% of the total variance present in the data (Table 1). Positive values of PC1 represent high total cover, vertical density, litter cover, and low vertical and horizontal heterogeneity. High positive values on PC1 are representative of undisturbed tall-grass prairie whereas large negative values represent vegetation that was disturbed either by fire or military activity. Positive values on PC2 represent high cover of standing dead vegetation, tall vegetation, high litter depth, and low cover of live grass and forbs, especially new growth close to the ground. Sites scoring highest on PC2 were those that had not been burned for three or more years, whereas those with negative values on PC2 were those burned earlier in 1996. Positive values on PC3 represent sites with high physiognomic diversity and relatively high indices of military disturbance.

Principal component scores for survey points on PC1 increased ($F = 78.4$; 2, 204 df; $P < 0.01$) from -1.3 in early spring ($n = 54$), to 1.4 in late spring ($n = 50$) and 2.5 ($n = 103$) by summer (Fig. 2). Values of survey points on PC2 were positive in early spring (0.73) and significantly different from late spring (-0.79) and summer (-0.72 ; $F = 23.2$; 2, 204 df, $P < 0.01$). Principal component scores on PC3 decreased from early spring (0.12) to summer (-0.52) and were intermediate in late spring (-0.13 ; $F = 6.06$; 2, 204 df; $P < 0.01$). Henslow's Sparrows use site scores did not differ among seasons on any PC axis, although there was a nearly significant difference ($F = 2.9$; 2, 18 df; $P = 0.08$) from early spring (2.09) to summer (-0.26) on PC2 (Fig. 2).

There was no significant difference in the density of shrubs between early and late spring combined Henslow's Sparrow use sites (10.08 ± 3.98 , $n = 13$) and early spring survey points (10.76 ± 1.95 ; $F = 0.02$; 1, 66 df; $P > 0.05$). However, Henslow's Sparrow use sites had significantly lower tree densities (0.54 ± 2.68) than survey points (6.67 ± 1.32 ; $F = 4.21$; 1, 66 df; $P = 0.04$). The mean value of PC1 (vegetative cover and density, litter cover, or structural homogeneity) on Henslow's Sparrow use sites ($n = 7$) in early spring was significantly higher than survey points ($F = 10.07$; 1, 59 df; $P = 0.02$), whereas early

TABLE 1. Eigenvectors of fine scale vegetative variables for the first three principal components determined by a PCA of Spring 1996 bird survey site herbaceous vegetation data at Fort Riley, Kansas. Factor loadings $<|0.30|$ are omitted.

| Variable | PC1 | PC2 | PC3 |
|--|--------|--------|-------|
| Eigenvalue | 6.11 | 3.15 | 1.66 |
| Variance explained | 47% | 24% | 13% |
| Cumulative variance | 47% | 71% | 84% |
| Cover in percent | | | |
| Total vegetation cover | 0.393 | | |
| Litter cover | 0.302 | | |
| Live grass cover | | -0.358 | |
| Live forb cover | | -0.336 | |
| Standing dead cover | | 0.374 | |
| Physiognomic diversity | | | 0.633 |
| Vertical structure | | | |
| Litter depth | | 0.454 | |
| Hits in first decimeter | | -0.401 | |
| Maximum height | | 0.330 | |
| Vertical density | 0.381 | | |
| Heterogeneity indices | | | |
| Coefficient of variation, vertical density | -0.379 | | |
| Coefficient of variation, maximum height | -0.359 | | |
| Military Disturbance | | | |
| Track index | | | 0.588 |

spring Henslow's Sparrow use sites did not differ significantly from survey points on PC2 ($F = 2.46$; 1, 59 df; $P > 0.05$) or PC3 ($F = 0.77$; 1, 59 df; $P > 0.05$) (Fig. 2).

During late spring, Henslow's Sparrows (n

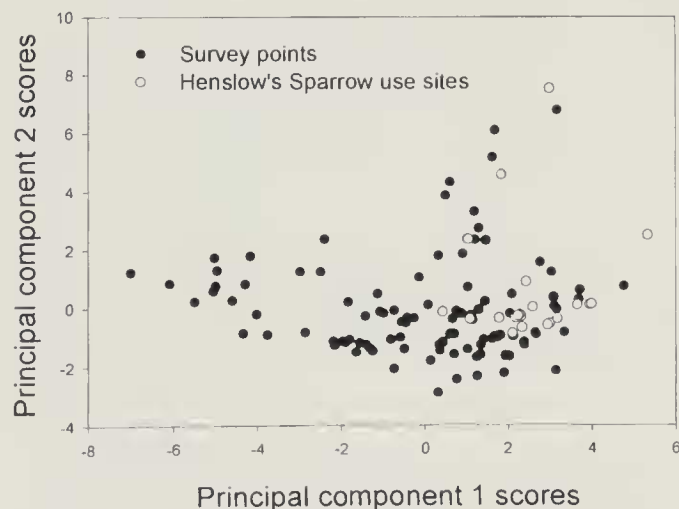


FIG. 3. Plot of Henslow's Sparrow use sites and survey points on principal components axes 1 and 2. Principal component 1 ordines from undisturbed tall-grass prairie to highly disturbed prairie. Positive values on principal component 2 represent high cover of standing dead vegetation, tall vegetation, and deep litter.

= 6) used habitats that were significantly different from survey points on all three principal components, although differences on PC1 were less than they had been in early spring. By summer, survey point scores had converged on the summer Henslow's Sparrow use sites ($n = 8$) to the extent that there were no longer significant differences on any PC axis (Fig. 2). All Henslow's Sparrow use sites combined were greater than zero on PC1 and had a higher mean value on PC2 than combined early and late spring survey points (Fig. 3). No significant differences existed with regard to the military track disturbance index between Henslow's Sparrow use sites and survey points during early or late spring, but they did diverge in summer (Table 2).

DISCUSSION

Henslow's Sparrows used open grassland habitat with few trees at both the large scale of habitat type and at the fine scale. At the fine scale the density of shrubs for Henslow's Sparrow use sites did not differ from the survey points. Thus, the presence of some low woody vegetation did not reduce Henslow's

TABLE 2. Comparison of 1996 military track disturbance index between Henslow's Sparrow use sites and random survey points at Fort Riley Military installation, Kansas. The military track index measures the severity of military disturbance to the vegetation and has a potential range of 0 to 300.

| Sampling period | Survey points | <i>n</i> | Henslow's Sparrow use sites | <i>n</i> | <i>P</i> |
|-----------------|-------------------------|----------|-----------------------------|----------|-------------------|
| Early spring | 59.2 ± 5.8 | 54 | 57.9 ± 11.9 | 7 | >0.05 |
| Late spring | 49.4 ± 1.1 | 50 | 57.9 ± 8.0 | 6 | >0.05 |
| Summer | 37.4 ± 2.5 ^a | 103 | 47.8 ± 3.4 ^a | 8 | 0.02 ^b |

^a Unequal variance estimates.

^b *P* value is the result of using unequal variance estimates. Difference of LS Means = -10.37, and SE of the difference = 4.19.

Sparrow use of the habitat at this scale. This is similar to observations of other authors who have also reported the presence of scattered bushes and shrubs in areas occupied by Henslow's Sparrows (Hyde 1939, Robins 1971, Bull 1974, Hanson 1994, Herkert 1994b).

None of the Henslow's Sparrows located on Fort Riley in 1996 were located in areas that had been hayed in 1995. Although 33 of 104 survey points were hayed in 1995, only 5 were in grassland sites, which were Henslow's Sparrows' preferred macrohabitat. Because the availability of hayed grassland sites in 1996 was low compared to the availability of non-hayed grassland, conclusions cannot be made from these data regarding the effects of haying on Henslow's Sparrow habitat selection at Fort Riley. Such conclusions will require long-term records regarding the frequency of harvest at survey and Henslow's Sparrow use sites. Because Henslow's Sparrows raise two to three broods per breeding season and nest as late as August (Robins 1971), hay cutting has the potential to directly affect the productivity of this ground nesting species (Smith and Smith 1992).

Most (96%) Henslow's Sparrow use sites at Fort Riley were located in sites last burned two or three years previously, a pattern of selection similar to that found in other studies (Herkert 1994b, Swengel 1996). During this study, 1993 burn sites were unique among other burned sites in that they reached the highest total vegetative cover and density (PC1) in late spring, rather than in summer, the pattern for 1994 and 1992 burned sites. This high cover and density early in the breeding season may have been important to Henslow's Sparrows establishing territories in April and May.

We found no differences in the severity of

military disturbance to the vegetation between survey points and Henslow's Sparrow use sites during spring; however, track disturbance was higher on Henslow's Sparrow use sites in summer. We attribute this to the flatter terrain in areas frequented by Henslow's Sparrows being more attractive to military operations. To conclude that military disturbance to the vegetation does not adversely affect site selection by Henslow's Sparrows is not yet warranted. Military disturbance to the vegetation can indirectly influence avian site selection by altering vegetative structure. For example, the pattern of military disturbance can affect vegetative structure by crushing and fragmenting patches of herbaceous vegetation and reducing the effectiveness of fire in localized areas. Furthermore, there is evidence that vehicular disturbance changes both the structure and composition of grassland vegetation by reducing cover by vegetation and litter and increasing cover by annual grasses and forbs (Johnson 1982, Wilson 1988, Shaw and Diersing 1990). Although these changes may be apparent in the vegetation within a season or two, they may take longer to affect bird habitat selection. We also noted that the bird territories were established before disturbance was measured. The direct and indirect effects of track disturbance on productivity are unknown and warrant further investigation.

The principal components analysis of vegetation at the survey points in early spring, late spring, and summer illustrates the habitat changes that occurred with plant growth through the growing season in tallgrass prairie habitats at Fort Riley. The mean scores of the survey points on PC1 increased through the season, reflecting the increasing importance of live grasses and forbs, and increasingly homogeneous vegetation as the seasons pro-

gressed. Principal component 2 scores declined as the seasons progressed, indicating decreasing prevalence of standing dead vegetation and a shift in importance from dead to live vegetation close to the ground. Permanent bird survey points score also declined on PC3 from early spring through summer, which indicated reduced physiognomic diversity and a lower incidence of vehicle tracks at survey points.

Henslow's Sparrow use sites did not differ significantly between sampling periods with respect to the measured vegetative variables despite concurrent changes in these variables through time for the survey points. This consistent pattern for the Henslow's Sparrow use sites suggests the importance of these vegetative variables to Henslow's Sparrow habitat selection. Vegetative characteristics consistently associated with Henslow's Sparrow use sites included high cover by litter and by dense, structurally homogeneous vegetation (high values of PC1). Mean values of PC2 (litter depth, and height and cover by standing dead vegetation) and PC3 (physiognomic cover diversity and disturbance index) did not differ between use sites and survey points during early spring. However, as mean values of PC2 and PC3 decreased across survey points during late spring, the difference between Henslow's Sparrow use sites and survey points became significant. Relative to survey points, Henslow's Sparrow use sites retained higher cover by standing dead vegetation and deeper litter (high values of PC2) in late spring. Those differences disappeared by summer. Scores on PC3 did not differ between Henslow's Sparrow sites and survey points during early spring; however, in late spring Henslow's Sparrow use sites and survey points were different. The differences identified in PC3, physiognomic diversity and track index, may be a result of sampling error. These results show, as Wiens (1989) noted, that the timing of studies investigating bird-habitat associations may greatly influence the detection of significant patterns of habitat selection.

At this time, management practices at Ft. Riley provide some habitat for Henslow's Sparrows. The desired practice of three year intervals for burns is appropriate; however, frequent wildfires reduce the amount of area suitable for Henslow's Sparrows. There are no

records of which areas are hayed each year, but all areas where we recorded Henslow's Sparrows are open to haying. Henslow's Sparrow habitat could probably be increased on Fort Riley by establishing a program to rotate areas available for haying among years to complement the fire rotation program. Ft. Riley currently provides important habitat for Henslow's Sparrows and other species and we encourage the Natural Resources staff to continue their good work.

ACKNOWLEDGMENTS

We wish to thank H. J. Able, K. A. Cherry, C. K. Jeffrey, D. P. Jones, J. Keating, B. C. Philips, M. M. Ponte, and C. Richardson of the Natural Resources Division at Fort Riley for their logistical help, help in the field, and encouragement. G. Hoch and R. Matlack helped establish the survey points, and P. Lemons helped collect large volumes of vegetation data. We thank G. Milliken and J. Pontius for their help with statistical questions. K. Beal, J. Cavitt, J. Herkert, D. Wolfe, J. Zimmerman, and an anonymous reviewer provided many thoughtful comments on the manuscript. We are grateful to the U.S. Army for providing funding support.

LITERATURE CITED

- ARBIB, R. 1979. The blue list for 1980. *Am. Birds* 33: 830-835.
- ASKINS, R. A. 1993. Population trends in grassland, shrubland, and forest birds in eastern North America. *Curr. Ornithol.* 11:1-34.
- BULL, J. 1974. *Birds of New York state*. Doubleday/Natural Henslowhistory Press, Garden City, New Jersey.
- GAUCH, H. G., JR. 1982. *Multivariate analysis in community ecology*. Cambridge Univ. Press, Cambridge, U.K.
- HANSON, L. G. 1994. The Henslow's Sparrow (*Ammodramus henslowii*) of Minnesota: population status and breeding habitat analysis. M.S. thesis, Central Michigan Univ., Mount Pleasant.
- HERKERT, J. R. 1994a. The effects of habitat fragmentation on midwestern grassland bird communities. *Ecol. Appl.* 4:461-471.
- HERKERT, J. R. 1994b. Status and habitat selection of the Henslow's Sparrow in Illinois. *Wilson Bull.* 106:35-45.
- HILL, M. O. 1973. Diversity and evenness: a unifying notation and its consequences. *Ecology* 54:427-432.
- HYDE, A. S. 1939. The life history of Henslow's Sparrow *Passerherbulus hensloi* (Audubon). *Misc. Pub. Mus. Zool., Univ. Mich.* 41:4-72.
- JAMES, F. C. 1971. Ordinations of habitat relationships among breeding birds. *Wilson Bull.* 83:215-236.
- JOHNSON, F. L. 1982. Effects of tank training activities

on botanical features at Fort Henslowood, Texas. *Southwest. Nat.* 27:309–314.

- KAHL, R. B., T. S. BASKETT, J. A. ELLIS, AND J. N. BURROUGHS. 1985. Characteristics of summer habitats of selected nongame birds in Missouri. *Agric. Exp. Station, Res. Bull.* 1056, Univ. of Missouri–Columbia, Columbia.
- KANSAS DEPARTMENT OF WILDLIFE AND PARKS. 1986. Summary of nongame task force actions related to developing three species lists: species in need of conservation, threatened and endangered. 1986 Nongame Task Force. Kansas Dept. of Wildlife and Parks, Pratt.
- LAUVER, C. L., W. H. BUSBY, K. KINDSCHER, AND J. L. WHISTLER. 1996. Identification and delineation of Loggerhead Shrike habitat on the Fort Riley Military Reservation. *Kans. Biol. Surv. Rept.* 69:1–30.
- MICHAELS, H. L. AND J. F. CULLY, JR. 1998. Landscape and fine scale habitat associations of the Loggerhead Shrike. *Wilson Bull.* 110:474–482.
- MILLIKEN, G. A. AND D. E. JOHNSON. 1984. Analysis of messy data. Lifetime Learning Publications, Belmont, California.
- PRUITT, L. 1995. Henslow's Sparrow status assessment. U.S. Fish and Wildlife Service, Indiana Field Office, Bloomington, Indiana.
- REICHMAN, O. J. 1987. Konza prairie: a tallgrass natural history. Univ. of Kansas Press, Lawrence.
- REYNOLDS, R. T., J. M. SCOTT, AND R. A. NUSSBAUM. 1980. A variable circular-plot method for estimating bird numbers. *Condor.* 82:309–313.
- ROBBINS, C. S., D. BYSTRAK, AND P. HENSLow. GEISLER. 1986. The breeding bird survey: its first fifteen years, 1965–1979. U.S. Dept. Interior, Fish Wildl. Serv., Res. Publ. 157:1–196.
- ROBINS, J. D. 1971. A study of Henslow's Sparrow in Michigan. *Wilson Bull.* 83:39–48.
- ROTEBERRY, J. T. AND J. A. WIENS. 1980. Habitat structure, patchiness, and avian communities in North American steppe vegetation: a multivariate analysis. *Ecology.* 61:1228–1250.
- SAMSON, F. AND F. KNOPE. 1994. Prairie conservation in North America. *Bioscience* 44:418–421.
- SAS INSTITUTE, INC. 1992. SAS/STAT Technical Report P-229, changes and enhancements, release 6.03 cd. SAS Institute, Inc., Cary, North Carolina.
- SAUER, J. R., J. E. HINES, G. GOUGH, I. THOMAS, AND B. G. PETERJOHN. 1997. The North American breeding bird survey results and analysis. Version 96.3. Patuxent Wildlife Research Center, Laurel, Maryland. URL = <http://www.mbrpwrc.usgs.gov/bbs/bbs.html>.
- SCHNEIDER, K. J. AND D. M. PENCE (Eds.). 1992. Migratory nongame birds of management concern in the Northeast. U.S. Dept. Interior, Fish Wildl. Serv., Newton Corner, Massachusetts.
- SHAW, R. B. AND V. E. DIERSING. 1990. Tracked vehicle impacts on vegetation at the Piñon Canyon Maneuver Site, Colorado. *J. Environ. Qual.* 19:234–243.
- SIMPSON, E. H. 1949. Measurement of diversity. *Nature* 163:688.
- SMITH, D. D. 1981. Iowa prairie an endangered ecosystem. *Proc. Iowa Acad. Sci.* 88:7–10.
- SMITH, D. J. AND C. R. SMITH. 1992. Henslow's Sparrow and Grasshopper Sparrow: a comparison of habitat use in Finger Lakes National Forest, New York. *Bird Observer* 20:187–194.
- SWENGEL, S. R. 1996. Management responses of three species of declining sparrows in tallgrass prairie. *Bird Conserv. Int.* 6:241–253.
- TATE, J., JR. 1981. The blue list for 1981—the first decade. *Am. Birds* 35:3–10.
- TATE, J., JR. 1986. The blue list for 1986. *Am. Birds* 40:227–236.
- TATE, J., JR. AND D. J. TATE. 1982. The blue list for 1982. *Am. Birds* 36:126–135.
- U.S. FISH AND WILDLIFE SERVICE. 1987. Migratory nongame birds of management concern in the United States: the 1987 list. U.S. Dept. Interior, Fish and Wildlife Service, Office of Migratory Bird Management, Washington, D.C.
- U.S. FISH AND WILDLIFE SERVICE. 1995. Migratory nongame birds of management concern in the United States: the 1995 list. U.S. Dept. Interior, U.S. Fish and Wildlife Service, Office of Migratory Bird Management, Washington, D.C.
- WIENS, J. A. 1969. An approach to the study of ecological relationships among grassland birds. *Ornithol. Monogr.* 8:1–93.
- WIENS, J. A. 1989. The ecology of bird communities. Cambridge University Press, Cambridge, U.K.
- WIENS, J. A. AND J. T. ROTEBERRY. 1981. Henslow habitat associations and community structure of birds in shrubsteppe environments. *Ecol. Monogr.* 5:21–41.
- WILSON, S. D. 1988. The effects of military tank traffic on prairie: a management tool. *Environ. Manage.* 12:397–403.
- ZAR, J. H. 1984. Biostatistical analysis, second ed. Prentice Hall, Englewood, New Jersey.
- ZIMMERMAN, J. L. 1988. Breeding season habitat selection by the Henslow's Sparrow (*Ammodramus henslowii*) in Kansas. *Wilson Bull.* 100:17–24.
- ZIMMERMAN, J. L. 1992. Density-independent factors affecting the avian diversity of the tallgrass prairie community. *Wilson Bull.* 104:85–94.